

Exhibit V

Data-Over-Cable Service Interface Specifications Technical Reports

DOCSIS 3.1 Profile Management Application Technical Report

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RELEASED

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1 SCOPE

1.1 Introduction and Purpose

CableLabs' DOCSIS 3.1 specifications introduced features that leverage the OFDM-based PHY layer, including variable bit loading, the ability to define multiple modulation profiles on downstream and upstream channels. Other DOCSIS features that need to be supported are upstream probes to check the quality of the upstream OFDMA signal, MAC Management messages to check the quality of a DS and test out profiles in use, etc. There are also extensive additions to important operational items like proactive network maintenance (PNM).

The configuration, initiation logic and compute processing needed to optimize some of these functions (e.g., Downstream (DS) Profile setup, Upstream IUC creation, or Load Balancing of CMs) are not defined in the DOCSIS 3.1 MAC and PHY specifications. This allows such functionality to be moved out of a CMTS and implemented as an "application" running outside the CCAP. Here the idea is to move the profile creation process as an application external to the CMTS. This application can communicate with the CCAP to gather the needed information, process the data, and make intelligent decisions to set up the CCAP as needed.

To realize this idea, the basic steps involve defining the data models and the selection of a protocol to convey the information used by a Profile Management Application (PMA) back and forth. The data models are essentially the information needed by the PMA to gather the needed data elements and performance data, make decisions based on that data, create updated or test profiles that are then instantiated on the channel and then inform the CCAP what DOCSIS 3.1 modems should be assigned to a given set of profiles. The protocol to convey the data and commands must be chosen well, so that every application or a controller which talks to the device on behalf of the applications can communicate easily with the devices.

To leverage the new OFDM/A PHY to its maximum benefit, different subcarriers use different modulation orders. Optimizing the downstream/upstream profiles allows a downstream/upstream channel to be able to operate with lower Signal-to-Noise Ratio (SNR) margin, potentially allowing a channel to operate at an overall higher throughput. The logic to achieve this can be external to a CCAP and enable innovation. For a cable operator, it allows uniform operation of such algorithms across different CCAP platforms.

1.2 Goals

The primary goals of this document are to define the architecture needed to enable a Profile Management Application (PMA), define the needed interfaces, define the information and data models enabling configuration of a DOCSISv3.1 CCAP by a PMA, and define the protocol for information exchange between the PMA and the CCAP. The PMA information model defines the data parameters needed by the profile management application and where to obtain those pieces of data. It also defines the interface between the PMA application and the CMTS. The same data could also be obtained from an external data collection server (e.g., PNM data collection). The protocol defined for PMA information exchange includes the operations needed, such as obtaining MER data and obtaining channel configuration. The second part of the protocol also then allows for setting the profiles on the CCAP for a CM. Typically a profile is created for a group of CMs, and assigned to each CM individually. The goal is to develop the needed APIs and RESTful interfaces as needed by a software developer.

5 DOCSIS 3.1 PROFILE MANAGEMENT APPLICATION

5.1 Introduction

With the inception of DOCSIS 3.1, the inclusion of OFDM downstream and OFDMA upstream channel types and a high degree of flexibility in using different modulation profiles with variable bit loading, it has become important to define a methodology that enables MSOs to maximize the bandwidth capacity in the HFC. Inspired by SDN Architecture and central to the methodology, a Profile Management Application (PMA) external to the CMTS has been envisioned that takes advantage of network components like the SDN controller and Proactive Network Management (PNM) servers to serve this network optimization function.

In the methodology, the PMA application will be able to identify operational CMTSs with OFDM and OFDMA channels, gather parameters of operating channels, query CMs, CMTS, and PNM servers for data, craft a modulation profile with bit loading that best suits the SNR signal strength at each of the subcarriers within a channel for any one modem, for a group of modems, or for all modems on that channel in case of multicast traffic, and apply modulation profiles to CMs and CMTSs. When the PMA is able to direct the CMTS and CMs to transmit with optimized modulation profiles, data will be transmitted at lower modulation order where SNR margins are lower and higher modulation order where SNR is high rather than transmitting on the entire channel with a single compromised modulation order, allowing for greater total throughput while still maintaining the fidelity of transmitted data.

While the CMTS has historically included DOCSIS-related features like load balancing and modulation profile management, the PMA function is not an intrinsic part of the DOCSIS MAC and PHY layers and can be implemented as an external "application" running outside the CMTS. An external PMA will exchange messages with CMTSs for monitoring, creating, modifying, and assigning modulation profiles. By deploying the PMA application external to any one CMTS, the operator will be able to deploy one PMA application solution across different CMTS platforms and achieve uniform operation of bit loading optimization algorithms. Additionally, the operator will free the PMA from the limited upgrade cycles of CMTS platforms and free the CMTS from the storage and computation requirements of the PMA application. Also, the PMA application can take advantage of external systems such as SDN controllers and PNM data lakes.

This document defines a methodology and associated data model, YANG schemas, and procedures, with which the PMA interacts with CMTSs, CMs, and other network elements to monitor, create, modify and then assign specific profiles to specific DOCSIS 3.1 CMs and fulfill the network optimization function.

5.2 Problem Description

5.2.1 Background

DOCSIS 3.1 introduced the concept of modulation profiles or bit loading characteristics for OFDM/A channels. A modulation profile is a list of modulation orders or bit loading configurations, defined for each subcarrier within an OFDM channel, or for each minislot in a OFDMA channel. A CMTS can define multiple modulation profiles/IUCs for use on a channel, where the profiles differ in the modulation orders assigned to each subcarrier or minislot. A CMTS can assign different downstream and upstream modulation profiles for different groups of CMs.

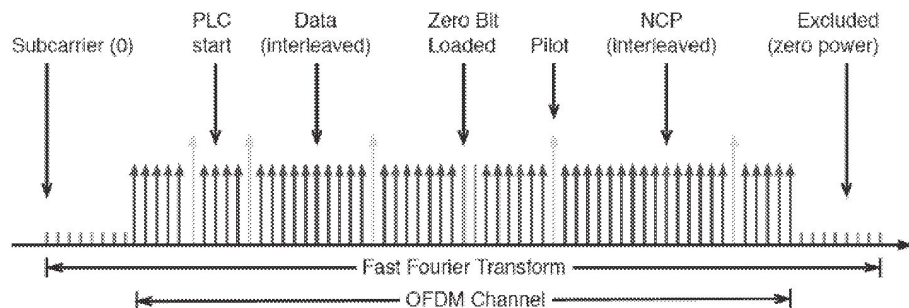


Figure 1 - DOCSIS 3.1 Downstream OFDM Channel